U. S. DEPARTMENT OF AGRICULTURE

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TIMOTHY

TIMOTHY, usually seeded in mixture with clover, is grown in rotations with other crops on most of the farms in the northeastern fourth of the United States.

Timothy is usually seeded with some grain as a nurse crop. Winter wheat and rye are generally better nurse crops than oats or other spring grains.

Fertilizers applied on corn, wheat, or other crops grown in rotation with timothy increase the following hay crops. Farm manure or nitrate of soda applied as a top-dressing on meadows is very effective in increasing the yields of timothy.

As a rule, timothy should be harvested for hay after the plants have passed out of full bloom, before any of the heads on the earliest plants have begun to turn brown and before the seed has begun to mature.

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TIMOTHY.

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EXTENT OF TIMOTHY GROWING.

TIMOTHY is adapted to a cool and humid climate rather than to one which is hot or dry. Most of the timothy grown in the United States is produced in the northern half of the country, east of the Missouri River. Timothy is grown on most of the farms throughout this region; it is the grass generally grown here for hay, and either alone or in mixture with clover it constitutes almost exclusively the hay sold in the market for feeding horses. It is also grown quite extensively in the Pacific Northwest.

According to the Fourteenth Census of the United States, 10,941,347 acres of timothy were grown alone (fig. 1) and 19,349,405 acres of timothy were grown in mixture with clover (fig. 2) in 1919. On this acreage 12,799,430 tons of timothy hay and 25,341,786 tons of mixed timothy and clover hay were produced.

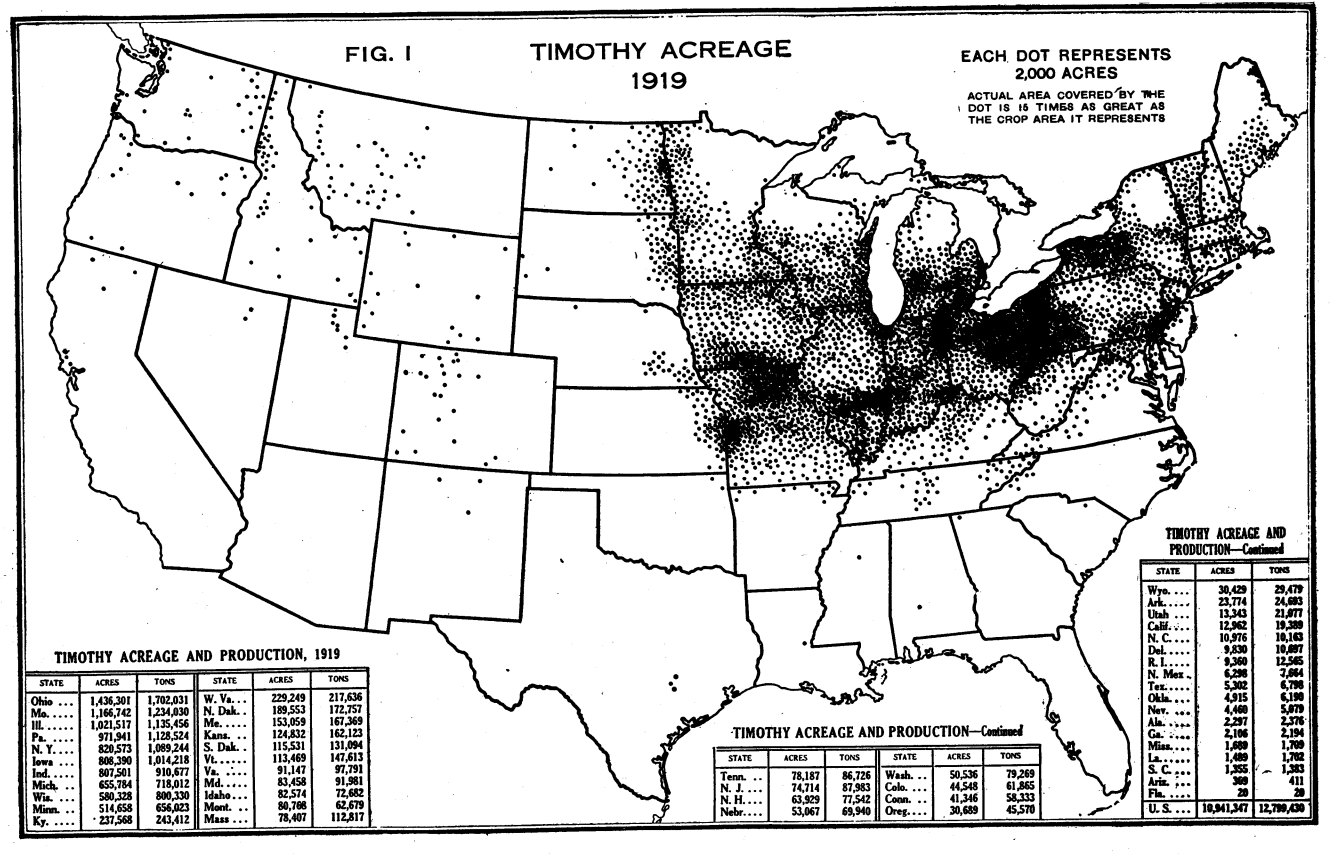
ROTATION OF CROPS.

The general practice in most parts of the United States is to grow timothy in more or less definite rotations rather than in permanent meadows. In those parts of the North Central States where both corn and winter wheat are important crops and where oats are grown, the most common rotation consists of corn, oats, and wheat, each one year, followed by hay crops from one to three years. On the more fertile soils of the Middle West, which are well suited to corn, the period in each rotation when the land is occupied by timothy is

FIG. 1 TIMOTHY ACREAGE 1919

EACH DOT REPRESENTS 2,000 ACRES

ACTUAL AREA COVERED BY THE DOT IS 16 TIMES AS GREAT AS THE CROP AREA IT REPRESENTS



TIMOTHY ACREAGE AND PRODUCTION, 1919

STATE	ACRES	TONS	STATE	ACRES	TONS
Ohio	1,436,301	1,702,031	W. Va.	229,249	217,636
Mo.	1,166,742	1,234,030	N. Dak.	189,553	172,757
Ill.	1,021,517	1,135,456	Me.	153,059	167,369
Pa.	971,941	1,128,524	Kans.	124,832	162,123
N. Y.	820,573	1,089,244	S. Dak.	115,531	131,094
Iowa	808,390	1,014,218	Vt.	113,469	147,613
Ind.	807,501	910,677	Va.	91,147	97,791
Mich.	655,784	718,012	Md.	83,458	91,981
Wis.	580,328	800,330	Idaho	82,574	72,682
Minn.	514,658	656,023	Mont.	80,768	62,679
Ky.	237,568	243,412	Mass	78,407	112,817

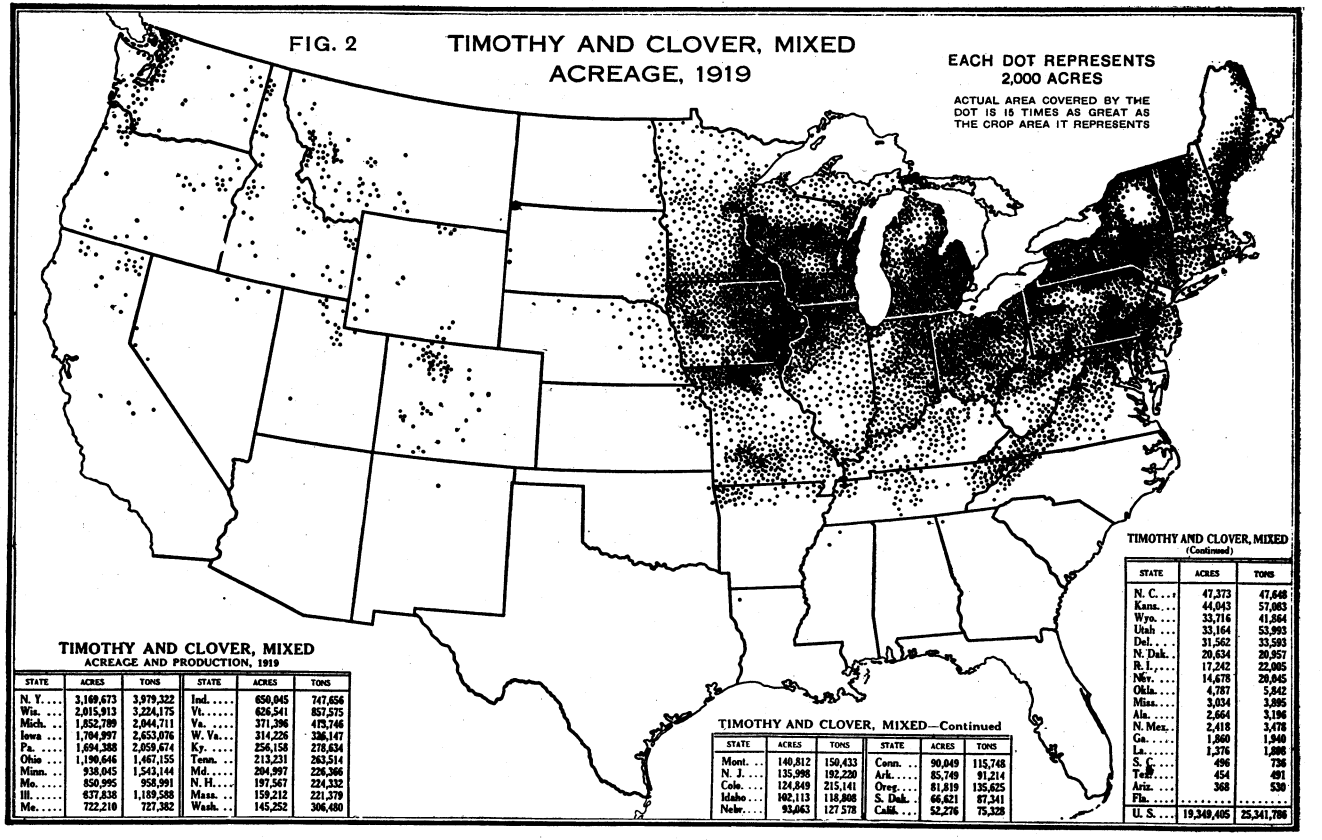
TIMOTHY ACREAGE AND PRODUCTION—Continued

STATE	ACRES	TONS	STATE	ACRES	TONS
Tenn.	78,187	86,726	Wash.	50,536	79,269
N. J.	74,714	87,983	Colo.	44,548	61,865
N. H.	63,929	77,542	Conn.	41,346	58,333
Nebr.	53,067	69,940	Oreg.	30,689	45,570

TIMOTHY ACREAGE AND PRODUCTION—Continued

STATE	ACRES	TONS
Wyo.	30,429	29,479
Ark.	23,774	24,683
Utah	13,343	21,977
Calif.	12,962	19,389
N. C.	10,976	10,163
Del.	9,830	10,697
R. I.	9,360	12,565
N. Mex.	6,298	7,984
Tex.	5,302	6,796
Okla.	4,915	6,199
Nev.	4,469	5,979
Ala.	2,297	2,376
Ga.	2,106	2,194
Miss.	1,689	1,769
La.	1,489	1,702
S. C.	1,355	1,383
Ariz.	369	411
Fla.	29	39
U. S.	10,941,347	12,799,436

FIG. 2 TIMOTHY AND CLOVER, MIXED ACREAGE, 1919



TIMOTHY AND CLOVER, MIXED
ACREAGE AND PRODUCTION, 1919

STATE	ACRES	TONS	STATE	ACRES	TONS
N. Y.	3,169,673	3,979,322	Ind.	650,045	747,656
Wis.	2,015,913	3,224,175	Vt.	626,541	857,575
Mich.	1,852,789	2,044,711	Va.	371,396	415,746
Iowa	1,704,997	2,653,076	W. Va.	314,226	336,147
Pa.	1,694,388	2,059,674	Ky.	256,158	278,634
Ohio	1,190,646	1,467,155	Tenn.	213,231	263,514
Minn.	938,045	1,543,144	Md.	204,997	228,366
Mo.	850,995	958,991	N. H.	197,547	224,332
Ill.	837,838	1,189,588	Mass.	159,212	221,579
Me.	722,210	727,382	Wash.	145,252	306,480

TIMOTHY AND CLOVER, MIXED—Continued

STATE	ACRES	TONS	STATE	ACRES	TONS
Mont.	140,812	159,433	Conn.	90,049	115,748
N. J.	135,998	192,220	Ark.	85,749	91,214
Colo.	124,849	215,141	Oreg.	81,819	135,625
Idaho	102,113	118,808	S. Dak.	66,621	87,341
Nebr.	93,063	127,578	Calif.	52,276	75,328

TIMOTHY AND CLOVER, MIXED
(Continued)

STATE	ACRES	TONS
N. C.	47,373	47,648
Kans.	44,043	57,083
Wyo.	33,716	41,864
Utah	33,164	53,993
Del.	31,552	33,593
N. Dak.	20,634	20,957
R. I.	17,242	22,005
Nev.	14,678	20,045
Okla.	4,787	5,842
Miss.	3,034	3,895
Ala.	2,664	3,196
N. Mex.	2,418	3,478
Ga.	1,860	1,940
La.	1,376	1,898
S. C.	496	736
Tex.	454	491
Ariz.	368	530
Fla.	.....	.....
U. S.	19,349,405	25,341,786

usually considerably less than the time devoted to grain. On such soils it is a common practice to harvest a mixed timothy and clover crop but one year in each 3-year or 4-year rotation. On soils well suited to grass, especially on rolling or hilly land where there is a clay soil which is easily eroded by heavy rainfalls when in cultivated crops, it is advisable to keep the field in meadow for a longer time.

Like other grasses, timothy not only protects the soil from erosion but also tends to improve its physical condition. The innumerable fine roots which penetrate into all parts of the surface soil break it up into small fragments. These roots do not live longer than about one year; new sets of roots are produced each season. The roots, stubble, and leaves of the plants which remain in the meadow after the hay crop has been removed add to the vegetable matter in the soil. A greater percentage of humus can be maintained in the soil and it can be kept in better tilth if the land is kept in meadow for a part of the time in each rotation than if it is used continuously for the culture of small grain, corn, or other clean-cultivated crops. For these reasons timothy and other perennial grasses are properly termed "restorative crops."

MIXTURES OF OTHER HAY PLANTS WITH TIMOTHY.

Timothy is generally sown in mixture with clover except in localities where the soil conditions are so unfavorable for clover that it can not easily be grown. When timothy and clover are seeded together, with some grain as a nurse crop, the first hay crop harvested is usually composed chiefly of clover. In the following seasons the meadow generally produces a crop of clear timothy hay, although on some soils and in favorable seasons there may be a small proportion of clover in the hay after the first year.

There are two or three important reasons for the practice of growing clover in mixture with timothy. The mixed timothy and clover hay has a higher feeding value for cattle and sheep than timothy alone. On soils where red clover grows well, if the first crop of timothy and clover is harvested comparatively early a second crop of clover can frequently be harvested in the same season, either for hay or for seed. Furthermore, a crop of clover will usually increase the productivity of the soil on which it is grown.

Timothy and red clover is the most common mixture in which timothy is grown. Sometimes mammoth clover is used, but this variety tends to produce such a large growth of coarse stems that the quality of the hay is not as good as that produced by medium red clover. For soils which are not well drained alsike clover is better adapted than red clover and is often substituted for red clover in such situations. On soils well suited for red clover, how-

ever, alsike clover does not produce as large yields of hay as the red clover, nor will it ordinarily produce a seed crop after the first hay crop has been harvested. Alsike clover has the merit that when it is being cured it does not become discolored as easily as red clover. For this reason timothy hay may contain a considerable percentage of alsike clover and yet sell in the market for approximately the same price as clear timothy.

On any soil where red clover can be grown, yet is not a sure crop, the practice of sowing both red and alsike clovers with timothy is recommended. This mixture is very commonly used in southern Michigan, northeastern Ohio, southern New York, and northern Pennsylvania on clay or silty loam soils which are poorly drained or deficient in lime or which for other reasons do not always produce satisfactory crops of red clover. In some seasons, when the red clover becomes badly winterkilled, most of the alsike clover may grow and produce a hay crop. When both red and alsike clovers survive the winter, a crop of hay composed of mixed timothy and red and alsike clovers is produced, which is considered by some farmers to have a higher feeding value than timothy and red clover.

In the New England States, in certain counties in southern Indiana and southern Illinois, and in some other parts of the United States it is a common practice to add redtop to the timothy and clover mixtures. Redtop is better adapted than timothy for growing on a wet or very acid soil.

In some localities alfalfa seed has been substituted for clover, and meadows have been developed which produce one crop of mixed timothy and alfalfa and a second crop of clear alfalfa hay each season.

SEEDING TIMOTHY.

PREPARATION OF THE SEED BED.

It is important that the seed bed for timothy be properly prepared. The soil should be well compacted, so that the surface layer will retain moisture well, or the seedlings may perish before they become well rooted, owing to a lack of available moisture. If the soil has been plowed for some time before seeding and the seed bed has been well compacted by disking and harrowing, it is not essential that all of the lumps on the surface be thoroughly pulverized by the use of a roller or plank drag. An ideal seed bed may be almost covered with small lumps of soil, 1 or 2 inches in diameter, which have been brought to the surface by cultural operations. If the timothy is sown in the fall, these lumps afford considerable protection to the seedlings during the following winter, preventing wind injury, the heaving of the soil, and other conditions unfavorable to the young

plants. An illustration of a good seed bed, such as has been described, is shown in figure 3.

NURSE CROPS.

In those parts of the timothy region where winter wheat or rye is grown, timothy is generally sown with one of these crops rather than with a spring grain. When seeded with winter grain, the timothy can be sown in the fall or very early in the spring, which enables the plants to form well-developed roots before the hot, dry summer weather. As winter grain is harvested earlier than spring grain, the competition between the grain and timothy plants for soil moisture or plant food is eliminated earlier in the season if winter wheat

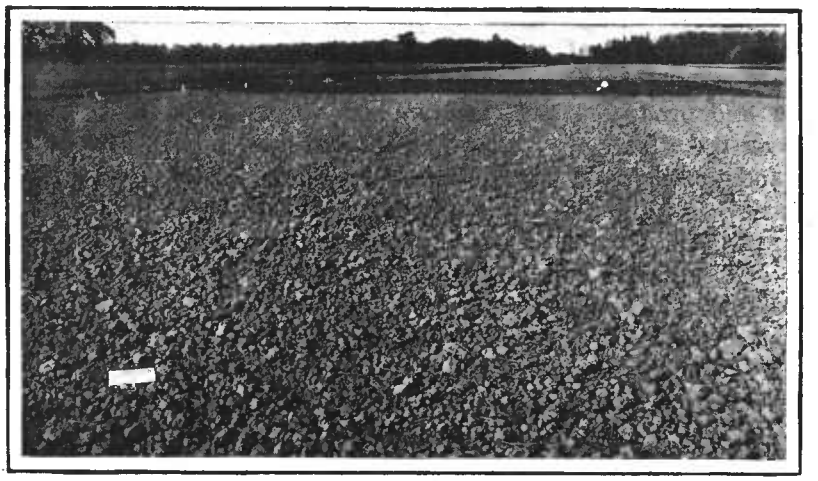


FIG. 3.—A well-prepared seed bed. The size of the lumps of soil, which have been pulled to the surface by the disk and spring-tooth harrow, is indicated by the piece of paper, which is 2 by 6 inches. These small lumps of soil help to protect the timothy seedlings during the winter.

or rye is used as a nurse crop than if the timothy is seeded with some spring grain. When seeded with a winter grain, the seed is generally sown on a well-compacted seed bed; when seeded with a spring grain, the timothy is often sown on soil plowed but a few days previously and on a seed bed too loose and open to be in the best condition for the growth of small timothy seedlings.

Throughout much of the timothy area winter wheat and rye are not grown, and for that reason timothy is seeded with a spring grain. Where barley or spring wheat is grown, either is regarded as a better nurse crop for timothy than oats, which make a denser and heavier growth. However, oats are more extensively grown than spring wheat or barley, and for this reason they are commonly used as a nurse crop for timothy in those parts of the timothy region where winter grain is not grown. If not exceeding 2 to $2\frac{1}{2}$ bushels of oats

per acre are sown, the grass seedlings will be shaded less than if the oats are sown at a heavier rate. Early-maturing short-strawed varieties of oats are better nurse crops for timothy than some of the large late-maturing varieties.

SEEDING TIMOTHY WITHOUT A NURSE CROP.

Timothy may be seeded alone instead of with a nurse crop in late summer or early fall. When seeded in this way a crop of timothy hay, which is usually very free from weeds, can be harvested in the following season, unless the young plants have been badly injured by unfavorable weather conditions during the winter. This method of seeding is especially recommended for use in Maryland, Virginia, and other States in the southern part of the timothy-growing area or in any locality where there may be difficulty in getting a good stand of timothy when it is seeded with a grain crop, because of the competition of weeds or for other reasons.

In the latitude of southern Maryland or Virginia clover may be seeded with the timothy provided the seed is sown not later than about August 15 to September 1. North of this latitude clover is likely to be winterkilled if sown in late summer or early fall. The timothy can be sown alone, however, and clover can be seeded on the field early in the following spring. If sown in the spring, clover will not make enough growth to produce hay in the first season, but in the second year the meadow will produce a mixed crop of timothy and clover if soil and climatic conditions have been favorable for the growth of the clover.

When timothy is seeded without a nurse crop in the fall, the seedlings will make a much more rapid and vigorous growth and therefore will be in better condition to go through the winter and produce a crop in the following season if the field is fertilized before the seed is sown. Fertilizers containing a large percentage of available nitrogen in the form of stable manure or nitrate of soda produce very marked beneficial effects on the growth of young grass plants. As nitrate of soda is very soluble and leaches from the soil rapidly during the winter months, fall applications of this fertilizer should not exceed 40 to 60 pounds per acre. Other fertilizers can be used at the rates suggested in the section of this bulletin where the use of fertilizers on meadows is discussed.

TIME OF SEEDING.

When timothy is seeded with winter wheat or rye the usual practice is to sow all or a part of the timothy in the fall at the same time as the grain. Soil and climatic conditions at that time are likely to be favorable for the germination of the seed and for the growth of the small timothy plants, provided the seeding is not delayed until late in the fall.

Some experiments have indicated that when timothy is sown at the same time as wheat in the fall the timothy sometimes makes a growth large enough to cause a considerable decrease in the wheat yield. Much of this injury to the wheat probably may be avoided by sowing only 2 or 3 pounds of timothy seed in the fall and the remainder with the clover in the spring. When all the timothy seed is sown early in the spring the timothy causes little or no decrease in the yield of wheat.

When timothy is sown in the spring with oats or any other spring grain it is generally desirable to sow as early as is consistent with the preparation of a good seed bed. The cool moist weather of early spring is likely to be more favorable for the germination of the seed and for the growth of the seedlings than the warmer weather of late spring.

When seeded alone in late summer or fall a better crop of hay may be expected if the timothy is seeded somewhat earlier than it is usually sown when seeded with winter wheat or rye. In the latitude of northern Ohio, although in favorable seasons timothy may be seeded alone as late as September 25, it is advisable to sow the seed during the first half of the month—preferably before September 10. In the latitude of Washington, D. C., timothy may be seeded as late as October 1. A better crop of hay may be expected, however, if the seed is sown early in September. In the southern part of this timothy-growing area clover may be seeded with the timothy if the seed is sown by August 15, or south of Washington, D. C., by September 1.

METHOD OF SEEDING.

Timothy seed should be sown at a depth less than 1 inch. Where grain drills are used a common practice is to place the timothy seed in the grass-seeder attachment on the drill and sow it at the same time as the grain. The tubes leading from the seeder attachment can generally be adjusted so that the seed will fall either ahead of the disks or hoes of the drill, where it will be covered lightly, or behind the disks or hoes between the loose particles and lumps on the surface of the seed bed, from which a light covering of soil will be washed over the seed by the first rainfall. If the timothy is sown broadcast immediately after the grain, the grass seed may be covered very lightly with a spike-tooth harrow or a weeder. If the timothy is sown in the spring with fall-sown grain, it can be mixed with clover and seeded broadcast with a hand seeder during the month of March and left to be covered by the alternate freezing and thawing of the soil. If seeding is delayed until later in the spring, it is a good plan to cover the seed by harrowing the soil lightly.

When timothy is seeded with a grain crop there is sometimes a failure to obtain a stand of grass; this is especially likely to occur in the southern part of the timothy area. When it is found that the

timothy seedlings have not survived through the summer the field can be plowed and prepared for reseeding the timothy without a nurse crop in late August or early September. Instead of plowing the field a very satisfactory seed bed can be prepared at a relatively small cost by disking the stubble as soon as possible after the grain has been harvested.

RATE OF SEEDING.

The quantity of seed which is sown with successful results in different localities or by different farmers in the same locality varies greatly. From 6 to 8 pounds of timothy and an equal quantity of red-clover seed per acre may be recommended as a satisfactory rate when the seed is sown with some grain crop. If alsike clover is to be included in the mixture, 5 pounds of red clover and 1 or 2 pounds of alsike clover can be sown with the timothy.

If the timothy is seeded alone instead of with a nurse crop, approximately 10 pounds of seed per acre should be sown.

In the New England States it is the common practice to sow more seed than has been recommended above. From 12 to 15 pounds of timothy per acre, and in addition about 4 pounds of redtop and 6 to 8 pounds of clover, one-third or more of which is alsike clover, is a common mixture used there.

THE USE AND EFFECT OF FERTILIZERS ON TIMOTHY.

In the Eastern States fertilizer in some form is generally applied to the soil at some time during each rotation in which timothy is grown. The usual practice is to apply the fertilizer to corn, wheat, or some other crop in the rotation rather than to the timothy.

EFFECT OF FERTILIZERS APPLIED TO PRECEDING CROPS.

When farm manure or some other fertilizer is applied to grain crops the yield of hay in the following years is usually increased.

In experiments conducted by the Ohio Agricultural Experiment Station crops were grown in a 5-year rotation, consisting of corn, oats, and wheat one year each, followed in the fourth year by a crop of mixed timothy and clover and in the fifth year by timothy. All the fertilizers used were applied on the corn and wheat.

Phosphorus was applied in the form of acid phosphate, potash in the form of muriate of potash, and nitrogen in both nitrate of soda and dried blood. Farm manure was used on two series of plats. Several plats were not fertilized, in order that the effect of the different fertilizers could be determined by comparing the yields obtained from the fertilized plats with those from the unfertilized plats.

On the plats where 320 pounds per acre of acid phosphate was applied to the grain crops in each rotation there was an average increase in the following hay crops of 515 pounds per acre of mixed timothy and clover and 310 pounds of timothy hay, compared with the unfertilized plats. On plats where 260 pounds of muriate of potash per acre was applied to the grain there was an average in-

crease of 242 pounds per acre of mixed timothy and clover and 126 pounds of timothy. On the plats on which nitrogen-containing fertilizers were used on the corn and wheat so as to make a total application of 440 pounds of nitrate of soda and 50 pounds of dried blood during each 5-year rotation, there was an increase in the following hay crops of 356 pounds per acre of mixed timothy and clover and 407 pounds of timothy.

On one series of plats, where a combination of all these fertilizers was applied to the grain crops at the rate at which each was applied singly to the plats referred to in the preceding paragraph, there was an average increase per acre of 1,407 pounds in the following crops of timothy and clover and 988 pounds in the yield of timothy.

Barnyard manure applied to the grain crops was very effective in increasing the subsequent crops of hay. On the series of plats where 8 tons of manure was applied during each rotation, one half to the corn and the other half to the wheat, there was an average increase of 1,138 pounds per acre in the following crops of mixed timothy and clover and 983 pounds in the crop of timothy. On the plats where a total of 16 tons of manure was applied to the grain during each rotation, there was an average increase above the yields obtained from the unfertilized plats of 2,082 pounds of mixed timothy and clover and 1,537 pounds of timothy hay per acre.

Where commercial fertilizers were used the greatest increase in the yields of hay was obtained from the plats where a combination of fertilizers containing phosphorus, potash, and nitrogen was applied to the grain. The largest returns on the money invested in commercial fertilizers, however, were obtained from the plats where 320 pounds of acid phosphate was applied during each 5-year rotation. The cost of the acid phosphate was much less, in proportion to the value of the increase in the hay crops, than that of the fertilizers containing either potash or nitrogen.

TOP-DRESSING MEADOWS WITH FERTILIZERS.

The yield of hay in timothy meadows may be increased by the application of fertilizers as a top-dressing. There is no better fertilizer for this purpose than farm manure. It may be applied in the fall, winter, or early spring. Although larger yields may be obtained from heavier applications, the greatest returns for each ton of manure used are likely to be obtained when 5 to 10 tons per acre is applied. If a timothy grower has a 10-acre meadow to be fertilized and if 50 tons of stable manure are available, greater profits may be expected from the use of this manure if it is applied at the rate of 5 tons per acre over the entire meadow than if only a part of the meadow was fertilized at the rate of 15 or 20 tons per acre.

In investigations conducted by agricultural experiment stations it has generally been found that nitrate of soda or some other fertilizer containing soluble nitrogen has produced a greater immediate effect on the growth of timothy than is produced by fertilizers containing either phosphorus or potash. On most soils throughout the timothy-growing area fertilizers containing phosphorus are more effective than those containing potash, although on some soils applications of potash do result in increased hay crops, usually through the increased growth of clover. Muck soils generally respond well to applications of potash.

As a rule, the largest increases in hay yield and the greatest benefits to succeeding crops are obtained when fertilizers containing a combination of nitrogen with phosphorus or with both phosphorus and potash are used. However, where meadows are maintained for only one or two years in each rotation it often may be found to be a better farm practice to use the phosphorus fertilizer, such as ground phosphate rock or acid phosphate, on the grain crops; the following crops of timothy will receive more or less benefit from the residual effect of the fertilizer applied on the grain. On the other hand, fertilizers containing a high percentage of nitrogen, such as nitrate of soda, may appropriately be used on the timothy meadow rather than on the grain crops.

Most of the mixed commercial fertilizers contain a smaller proportion of nitrogen than is desirable for use on timothy meadows. A better combination for top-dressing meadows can be obtained by mixing together in proper proportions fertilizers containing nitrogen and phosphorus. A mixture composed of 100 to 150 pounds of nitrate of soda and 150 to 250 pounds of acid phosphate per acre would provide a good combination of fertilizers to use on a timothy meadow. This fertilizer should be applied early in the spring, soon after the grass begins to grow. On soils which respond well to applications of potash, from 50 to 100 pounds per acre of either sulphate or muriate of potash can be added to this mixture. If a fertilizer containing nitrogen only is to be used instead of the mixture which has just been suggested, nitrate of soda may be applied alone at the rate of 100 to 150 pounds per acre.

The Indiana Agricultural Experiment Station applied fertilizers in the spring in each of two successive seasons on plats in a timothy meadow. Applications of 100 pounds of nitrate of soda per acre resulted in an average increase of 1,487 pounds of hay per acre. On plats where a combination of 100 pounds of nitrate of soda, 200 pounds of acid phosphate, and 100 pounds of muriate of potash per acre was applied, there was an average increase of 2,404 pounds of hay per acre. On plats where 10 tons per acre of farm manure was

applied there was an average increase of 1,595 pounds of hay per acre each year.

At the Cornell University Agricultural Experiment Station two applications of 10 tons of manure each, one of which was applied before the meadow was seeded, the other after the second crop of hay was harvested, resulted in an average annual increase during the three years that the field was in meadow of 2,975 pounds of hay per acre above the yields produced on unfertilized plats.

When a timothy meadow which has been fertilized is plowed and used for the production of other crops the yields of these crops are ordinarily greater as a result of the fertilizers used on the meadow. This residual effect is due in part to the heavier sod produced by the fertilizers, and it may be due in part to the direct effect of those portions of the fertilizers remaining in the soil which are not used by the plants in the first season. Nitrate of soda is very soluble, and it leaches from the soil readily; therefore any benefit which crops in following seasons derive from it may be attributed chiefly to the heavier sod resulting from its use. Fertilizers containing phosphorus or potash are less soluble; their direct effect on the crops may continue for several years.

In a series of experiments conducted at the Cornell University Agricultural Experiment Station timothy plats which had received different fertilizer treatments during a period of three years were plowed and a crop of corn was grown on them. On the plats where 160 pounds of nitrate of soda had been applied annually to the timothy the corn yielded 5.3 bushels per acre more than on the plats where no fertilizer had been applied. On the plats where 320 pounds of acid phosphate had been applied annually to the timothy the corn yielded 3.5 bushels per acre more than on the unfertilized plats. On the plats where a combination of 160 pounds of nitrate of soda, 320 pounds of acid phosphate, and 80 pounds of muriate of potash per acre was applied annually on the meadow the corn produced 23.6 more bushels per acre than on the unfertilized plats. On plats where two applications of 10 tons each per acre of farm manure had been applied to the timothy the corn produced 35 bushels per acre above the yield from the unfertilized plats. In the second year after the meadow was plowed a larger crop of oats was produced on all the fertilized plats than on the unfertilized plats. On the plats where stable manure had been applied its effect was apparent in the increased yield of wheat for three years after the meadow was plowed.

Whether commercial fertilizers can be profitably applied on timothy meadows depends largely on the relative prices of fertilizers and hay. When the prices for fertilizers are abnormally high it may not be possible to use them on timothy with financial gain. On

the other hand, when fertilizers can be purchased at normal prices they can frequently be used with profit, especially by timothy growers located near good markets for hay.

Some of the conditions under which the use of fertilizers as a top-dressing on timothy meadows may or may not be profitable are suggested by the results of an experiment conducted by the New Jersey Agricultural Experiment Station. Nitrate of soda was applied on portions of two meadows at the rate of 100 pounds per acre. There was an average increase of 1,140 pounds of hay per acre due to the fertilizer used. The nitrate of soda used cost $2.25 per acre. As hay was worth $10 a ton, the value of the increased yield due to the nitrate of soda was $5.70 per acre. Deducting the cost of the fertilizer, there was left a balance of $3.45 per acre to pay the interest on the money invested in the fertilizer, the cost of applying the fertilizer, and to meet the expenses of handling the larger crop of hay and to cover the profit. If the same results should be obtained from an application of the same quantity of nitrate of soda at the same cost in a locality where hay is worth $16 a ton, the value of the increased yield would be $9.12 per acre. After the cost of the fertilizer is deducted there would be a balance of $6.87 instead of $3.45 per acre to pay for the additional cost of producing the larger crop and to constitute the profit.

When the cost of nitrate of soda is abnormally great, as when war conditions have created an unusual demand for its use for manufacturing explosives, it can not economically be used on timothy unless the price of hay is also high. If nitrate of soda sells for $100 a ton instead of at the normal price of approximately $50 and if timothy hay is worth $10 a ton, an increase of 1,000 pounds of hay per acre which might result from the application of 100 pounds of nitrate of soda would just pay the cost of the fertilizer used and there would be no balance to cover the other expenses. On the other hand, in any locality where there is a market for hay at $25 or more a ton, it may be possible to use nitrate of soda with profit even when it costs double the usual price.

THE RELATION OF LIME TO THE GROWTH OF TIMOTHY.

In many localities, especially in the Eastern States, where the soil is more or less acid, larger hay crops are frequently harvested after the use of lime, which is ordinarily applied on some grain crop grown in rotation with timothy. When any increase in yield results from the use of lime it is usually the greater growth of the clover growing in mixture with the timothy rather than the larger growth of the timothy which is chiefly responsible for the increased quantity of hay harvested. However, the timothy is likely to obtain an indi-

rect if not a direct benefit from the lime, for when timothy or any other grass is growing in association with clover, alfalfa, or some other legume the grass often makes a more rapid growth and contains a larger proportion of protein than grass growing in a similar soil but not in mixture with a leguminous crop.

The need of lime on any soil is likely to be indicated by the failure of clover to make a satisfactory growth before there is any apparent decrease in the growth or yield of timothy. Wherever good crops of clover are obtained, it may be assumed that lime would be of little benefit to timothy.

In fertilizer investigations conducted at the Ohio Agricultural Experiment Station lime has been applied since 1900 once in each 5-year rotation after the land has been plowed for corn. At first burned or caustic lime was used at the rate of 1 ton per acre. In later applications, an equal quantity of ground limestone was substituted. This contains only about half as much actual lime, or calcium, as the burned lime. It has become apparent in recent years that 1 ton of ground limestone is not sufficient to give the best yields on the soil where these experiments are being conducted. For that reason, since 1914 the quantity of ground limestone used has been increased to 2 tons per acre.

The average yield of mixed timothy and clover harvested during a series of 11 years, 1903 to 1913, inclusive, was 574 pounds per acre greater on the limed than on the unlimed plats. The average yield of timothy alone harvested in the second year of each rotation when the land produced a crop of hay during the same period was 713 pounds per acre greater on the limed plats.

The following comments on the effect of lime on the growth of timothy are quoted from Bulletin 279 of the Ohio Agricultural Experiment Station:

> The total gain for lime in the timothy has been greater, and the percentage gain nearly as great as in the clover, and in both it has been much greater than in the oats or wheat, notwithstanding the fact that these crops have been grown at an earlier period after liming than the clover and timothy. The increase in the timothy crop may be accounted for in part in the advantage gained by its association with clover.

PASTURING THE MEADOWS.

It is a common practice to allow live stock to graze on timothy meadows at some time during the year. A very large proportion of farmers pasture the meadows more or less during the late summer and fall. Few experimental data are available to indicate what effect fall pasturing has upon the following season's hay crop. If there is a comparatively large growth of aftermath, the meadows may

be used for pasture without serious injury, provided the grass is not grazed very closely at any time and the animals are kept off the meadows when the soil is wet and soft.

Meadows are less frequently pastured during the spring months. It is the opinion of most timothy growers that grazing the meadows at this time injures the crop to such an extent that the practice is not profitable.

In many sections where timothy is grown, especially where dairying is an important industry, it is very common to use the meadow for the production of hay for one or two seasons; then to pasture it for one or more entire seasons before plowing the land for other crops.

WEEDS.

While there are a large number of weeds which grow in timothy meadows, comparatively few of them are serious over very much of the timothy area. Most of the common annual weeds, such as ragweed and pigeon grass, which grow in grain fields or in cultivated crops are not serious pests in meadows, although they may seriously compete with the small timothy plants in recently seeded fields. A few of the winter annuals, i. e., plants which germinate from seed in the late summer or early fall and mature in the following summer, are among the most troublesome of the weeds which grow in timothy. In this class are included shepherd's-purse and also common and field peppergrass. While these weeds are not very common in older meadows, they are among the worst of the weeds which grow in recently seeded meadows before the timothy plants are fully developed. Squirreltail grass, or wild barley, a winter annual, is a serious weed in many timothy meadows, especially throughout the Western States. "Whiteweed," or fleabane, another winter annual, is a more or less serious weed in established meadows in practically all regions where timothy is grown.

Aside from these winter annuals most of the common weeds in timothy meadows, such as wild carrot, are biennials or, more frequently, perennials, such as sheep sorrel, various species of dock, plantain, oxeye daisy, and quack-grass.[1]

Weeds are frequently introduced into meadows with the seed of timothy or clover in which the weed seeds are present as an impurity.

[1] The botanic names of the most common species of weeds which have been mentioned are as follows: Shepherd's-purse, *Capsella bursa-pastoris;* common peppergrass, *Lepidium virginicum;* field peppergrass, *Lepidium campestre;* fleabane, *Erigeron annuus;* wild carrot, *Daucus carota;* sheep sorrel, *Rumex acetosella;* dock, *Rumex* spp.; oxeye daisy, *Chrysanthemum leucanthemum;* quack-grass, *Agropyron repens;* squirreltail grass, *Hordeum jubatum.*

Weeds sometimes develop in the meadows from seeds which have lain dormant in the soil for several years. The seeds may be brought in by the wind or by water flowing over the field, or they may be carried and distributed in different ways by live stock pasturing in the field. Some weeds, such as fleabane and oxeye daisy, produce large quantities of seed which matures early and is likely to shatter and become distributed over the meadow before the hay crop is harvested; their seeding habits enable the plants of these species to reproduce themselves in the meadows in very large numbers.

One of the most effective ways to combat weeds in meadows is to have the soil in a condition favorable for the growth of grass. This fact is well illustrated by two plats at the Missouri Agricultural Experiment Station which were seeded with timothy more than 20 years ago and have been kept as a permanent meadow since that time. When these plats were observed in 1916, on one plat which had received no fertilizer since the timothy was seeded there were a large number of weeds, chiefly whiteweed, and a comparatively small growth of timothy, while on the other plat, which has received liberal applications of fertilizer, there was a large and dense growth of timothy, with very few weeds growing in mixture with it.

If the timothy seed is properly sown and a uniform stand of grass obtained over the meadow, weeds are not as likely to become serious as if the seed is sown too thinly or unevenly.

Where large coarse plants, such as certain species of dock, are growing in different parts of the meadow, the quality of the hay may sometimes be improved with profit by going through the meadow and pulling or grubbing out the weeds. Ordinarily, however, when weeds are once established in a timothy meadow, they may be eradicated most effectively by plowing the land and cultivating the other crops which are ordinarily grown in rotation with the timothy.

HARVESTING AT DIFFERENT STAGES OF DEVELOPMENT OF THE PLANTS.

EFFECT OF STAGE OF DEVELOPMENT ON YIELD.

The time when timothy is harvested for hay in any particular locality often extends over a period of a month or more. The time of harvesting is determined not only by the yield and quality of hay obtained when it is cut at different stages of development of the plants, but also by weather conditions, by the pressure of other farm work, and sometimes by other factors.

The Missouri Agricultural Experiment Station conducted an investigation to determine the effect on the yield of harvesting timothy when the plants were at different stages of development. The crop

was cut in three different seasons at each of five stages of development, as follows: (1) When the plants were partly in bloom, (2) when the plants were in full bloom, (3) when the seed had formed, (4) when the seed was in the dough stage, and (5) when the seed was ripe but not shattered. The average yield of field-cured hay at each time of cutting and the relative yield, taking the highest yield obtained as 100, are shown in Table I.

TABLE I.—*Average yield per acre of timothy hay cut at five different stages of growth at the Missouri Agricultural Experiment Station.*

Stage of growth when cut.	Yield.	
	Actual.	Relative.
	Pounds.	*Per cent.*
First cutting, partly in bloom	5,180	89.4
Second cutting, full bloom	5,433	93.8
Third cutting, seed formed	5,793	100
Fourth cutting, seed in the dough stage	5,750	99.3
Fifth cutting, seed fully ripe	5,193	89.7

The largest yields of hay were obtained from the cuttings made after the seed had formed but before it was matured. The difference in yield between the third and fourth cuttings was slight, averaging but 43 pounds of hay per acre. The average difference between the yields of the first and last cuttings was small, but these cuttings produced on an average between 500 and 600 pounds less hay to the acre than the third and fourth cuttings.

EFFECT OF STAGE OF DEVELOPMENT ON THE FEEDING VALUE OF THE HAY.

The value of the crop which may be harvested from an acre of timothy depends not only on the number of pounds of field-cured hay which may be obtained but also upon its quality. The value of the hay for feeding may be measured by the amount of digestible matter which it contains, by its palatability, and in other ways. The feeding value of timothy hay harvested when the plants are at different stages of development is illustrated by the results of another series of experiments conducted by the Missouri Agricultural Experiment Station.

The timothy which was cut at the five different stages of growth was fed to steers and a study was made of the proportion of each cutting which was digested. It was found that the earlier cuttings of hay were more completely digested than were the later ones. For this reason the cutting which produced the largest weight of cured hay per acre did not produce the largest yield of digestible nutrients, as is shown in Table II.

TABLE II.—*Average yield per acre of digestible dry matter in timothy hay cut at five different stages of growth at the Missouri Agricultural Experiment Station.*

Stage of growth when cut.	Yield.	
	Actual.	Relative.[2]
	Pounds.	*Per cent.*
First cutting, partly in bloom	1,995.7	91.7
Second cutting, full bloom	2,175.3	100
Third cutting, seed formed	2,038.8	93.7
Fourth cutting, seed in the dough stage	1,913.7	87.9
Fifth cutting, seed fully ripe	1,774.8	81.6

The maximum yields of digestible dry matter, including the digestible protein, digestible crude fiber, digestible ash, and digestible carbohydrates, were obtained from the second cutting, when the plants were in full bloom. From this stage there was a gradual decline in the quantity of digestible matter. The fifth cutting, harvested when the seed was ripe but not shattered, yielded scarcely more than four-fifths as much digestible dry matter as the second cutting, when the plants were in full bloom.

Hay which was cut at the different stages of growth was fed to steers, dairy cows, and sheep in order to study the preference of these animals for the different cuttings. At different times 100 pounds of each of the cuttings of hay was put into a feed rack, each cutting being placed in a separate compartment, and the stock which were being fed were allowed free access to the different growths of hay in the rack.

The following description of the results of this experiment is quoted from Research Bulletin No. 19 of the Missouri Agricultural Experiment Station:

> Yearling steers subsisting entirely on hay in every case showed preference for the different cuttings in the order in which they were cut. The fourth and fifth cuttings were left almost untouched until the hays from all earlier cuttings had been entirely eaten. Milk cows, having grain and other roughage besides the hays under test, were not so discriminating in their taste as regards the first three cuttings, but they, like the steers, left the fourth and fifth cuttings almost untouched until the first, second, and third cuttings were eaten. Sheep, full fed on mixed grain, appeared to eat one cutting with as much relish as another.

THE STAGE OF DEVELOPMENT AT WHICH TIMOTHY SHOULD BE HARVESTED.

The experiments indicate that the timothy grower should harvest the hay as soon as the plants are in full bloom, but there are several reasons why it is generally better to delay haying operations until a little later, even though there is some decrease in the yield of digestible matter.

[2] The highest yield in each case is taken as 100 per cent, and the other statements of relative yield are based upon it.

Timothy hay which has been harvested when the plants are in full bloom is likely to be more or less dusty because of the pollen which falls from the flowers and becomes mixed with the hay. This makes it somewhat objectionable for feeding, especially to horses. When timothy is in full bloom, the plants contain a larger percentage of moisture and cure more slowly than later. For this reason the danger of having the hay injured by unfavorable weather while it is being cured is greater if the plants are harvested at this stage than if they are more nearly mature. Furthermore, at the time when timothy is in full bloom, other farm work, such as the wheat or clover-hay harvest or the cultivation of corn, is likely to require attention and make it desirable to delay the harvesting of timothy hay until later.

All things considered, the best stage to cut timothy hay is at any time within a few days after the plants have passed out of bloom. After this there may be a decrease in the yield and a still more rapid decrease in the feeding value of the hay.

The actual dates for harvesting timothy in the best condition vary in different parts of the country. In the latitude of northern Ohio in ordinary seasons the time extends approximately from July 5 to 20. In the southern part of the timothy-growing area the best time for harvesting the hay is a few days earlier, while in Minnesota or in northern Wisconsin or Iowa it is a few days later than the dates given for northern Ohio.

In meadows composed of a mixture of timothy and clover the time when the hay should be harvested depends largely upon the relative proportion of these plants in the mixture. If the hay is more than half clover, it should be cut at the stage when the clover is in the best condition, which is usually two or three weeks earlier than the best time for harvesting a crop of clear timothy hay.

HAYING MACHINERY.

EQUIPMENT NECESSARY FOR HARVESTING HAY.

The type of haying machinery which should be used on any particular farm and the amount of capital invested in special haying machinery depend largely upon the acreage devoted to the production of hay. A mowing machine, a dump rake (fig. 4), and hay rigging to be used on the farm wagon, together with a track, ropes, and pulleys, and a hay fork or sling in the barn where the hay is to be stored, may be all the machinery which can be used economically on farms where the acreage of timothy or other hay crops is not large. On farms where large quantities of timothy are produced, particu-

larly if it is difficult to obtain farm labor, more special haying machinery may be used.

THE SIDE-DELIVERY RAKE.

Side-delivery rakes are now being used quite extensively, particularly on farms where hay loaders are in use. The side delivery rake makes a continuous, comparatively uniform windrow (fig. 5). The hay can be gathered with a hay loader somewhat more readily from

FIG. 4.—Mowing timothy hay. (Upper view.) Gathering timothy hay with a dump rake. (Lower view.)

these windrows than from those made with an ordinary dump rake. The side-delivery rake turns the hay over in such a way that the under parts of the swath are turned upward, and thus it does to some extent the same work that is performed by the hay tedder.

THE HAY TEDDER.

Besides the machinery already mentioned, the hay tedder is frequently included in the haying equipment (fig. 5). It is particularly useful for turning over and exposing more thoroughly to the air mixed timothy and clover or heavy crops of clear timothy cut

early in the season while the plants are comparatively green. The tedder should be used before the hay lying on the surface of the swaths has become thoroughly dry, or some loss may be caused by parts of leaves, stems, and heads being broken off. When timothy is harvested comparatively late in the season it will usually dry so rapidly that the use of the tedder is unnecessary.

THE HAY LOADER.

Hay loaders are extensively used on farms where large areas of hay are grown (see the illustration on the title-page). The hay is sometimes taken directly from the swath with the loader. Unless the

FIG. 5.—Raking timothy hay. The side-delivery rake makes a continuous, uniform windrow, from which hay can readily be gathered with a hay loader. (Upper view.) Tedding timothy hay. The tedder is useful for stirring and turning over heavy crops of hay, especially during the early part of the harvesting season, when the plants contain a relatively high percentage of moisture. (Lower view.)

yield is large, however, it can be gathered more quickly by first raking it into windrows. A second objection to gathering the hay from the swaths with the hay loader, particularly if there is a heavy crop which is harvested early in the season, is that many of the leaves become so brittle by the time all the hay is dry enough to haul to the barn that there is likely to be considerable loss of leaves which are broken off.

Hay can be harvested more rapidly and with less labor when side-delivery rakes and hay loaders are used, but the quality is generally

not so good as when the hay is cured in cocks (fig. 6). Hay loaders are not so well suited for use on rough or hilly land as on that which is level or gently rolling.

THE SWEEP RAKE AND STACKER.

On many of the farms in Missouri and in some of the other West-Central States where large areas of timothy are grown and where a large proportion of the hay is stored in stacks or ricks, the hay is gathered from either the swath or windrow by means of sweep rakes. The hay is hauled on the sweep rake instead of on a wagon and is unloaded by means of a stacker or ricker (fig. 7).

Sweep rakes are also used to a limited extent in the Eastern States to haul hay from the field to the barn.

FIG. 6.—Curing timothy hay in cocks. The best quality of hay can be obtained when it is cured in well-made cocks.

YIELDS OF HAY.

According to statistics obtained in the Thirteenth Census of the United States the average yield of timothy in this country in 1909 was 1.22 tons per acre.

The yields of hay actually harvested in different places and seasons vary widely. In localities where the soil and climate are well suited for the growth of timothy the average yield of hay on well-managed meadows should be 1½ tons or more per acre, and under very favorable conditions yields of 2½ tons or more per acre may be obtained.

After the second or third season that a field is in meadow, unless the yields are maintained by applications of fertilizers, the tendency is for the quantity of hay harvested to decrease.

STORING THE HAY.

The ideal way of storing hay is to place it in barns or hay sheds, where, if properly cured, it can be preserved in good condition, without further loss from weathering, until it is fed or marketed.

When hay is stored in stacks or ricks there is obviously a greater loss in its feeding or market value than if it were stored in barns. The actual extent of this loss is affected by the climatic conditions and by the methods of stacking. In the Eastern States hay in stacks is likely to be damaged to a greater extent by unfavorable weather than in those parts of the West where the annual rainfall is less. If a quantity of hay is placed in several small poorly made stacks a larger proportion of it will be exposed to the weather and the percentage of loss will therefore be greater than if it were placed in a single large well-made stack (fig. 8).

The sides of the stack should be straight up and down or they should slope outward slightly from the ground upward. The middle of the stack should at all times be kept somewhat higher than the

FIG. 7.—Stacking timothy hay. Sweep rakes and stackers are used on many farms in the West-Central States, where a large proportion of the hay is stored in stacks or ricks.

outer parts. When the stack is completed there should be a sharp slope from the peak or ridge down to the sides. A covering of wheat or rye straw will aid in turning water from the stack and in protecting the hay from the weather.

LOSS IN WEIGHT OR FEEDING VALUE OF THE HAY DURING STORAGE.

Even when hay is placed in barns it usually loses more or less in weight from the time when it is stored to the time when it is used, several months later. This decrease in weight is largely due to loss of moisture. When field-cured timothy hay is hauled to the barn it ordinarily contains from 15 to 25 per cent and sometimes as much as 30 per cent of moisture. Hay which has been stored in a barn for several months contains an average of about 12 per cent of moisture.

Other causes also result in loss of weight of hay stored in barns. The development of such organisms as bacteria or molds and the action of certain enzyms bring about chemical changes which

result in a decrease in the weight of the protein, crude fiber, carbohydrates, and other constituents of the dry matter itself.

Unless it was exceptionally dry when stored, hay which has been kept in barns for six months or more generally weighs from 10 to 20 per cent less than when it was placed in the barn. The decrease in weight is sometimes less and sometimes greater than indicated above. A decrease of 10 per cent in weight in six months would mean that hay which weighed a ton when placed in the barn would weigh only 1,800 pounds at the end of that time. Unless the hay

FIG. 8.—Timothy hay in small poorly made stacks. If a given quantity of hay is placed in several small poorly made stacks, a larger proportion of it will be exposed to the weather and the percentage of loss will be greater than if it were placed in one large well-made stack. (Upper view.) Ripe timothy in shocks. This grass, when grown for seed, is usually harvested with a grain binder and the bundles placed in shocks, where they remain until dry. (Lower view.)

has become dusty or moldy it may be assumed that most of this decrease in weight is due to loss of moisture and that there has been little or no change in the feeding value of the hay.

SEED PRODUCTION.

The crop on a timothy meadow may be utilized for either hay or seed. Frequently the timothy grower harvests most of the crop for hay, but reserves a small area for the production of seed to be used on the farm during the following year.

Timothy should be harvested for seed when most of the heads have become brown and the seed is beginning to shatter from the extreme tips of a small proportion of the earliest heads. It is usually harvested with a grain binder, cured in shocks (fig. 8), and thrashed with an ordinary thrashing machine.

The yields of seed vary, depending largely on the density of the growth of the timothy. They ordinarily range from 3 to 8 bushels per acre, and 5 or 6 bushels of seed per acre may be considered a fair crop. The legal weight of timothy seed in most of the States is 45 pounds per bushel.

While the value of thrashed timothy straw for feeding is much less than that of timothy hay cut at the proper time, yet when the crop is cured and thrashed without being damaged much by rains the straw frequently has considerable feeding value.

COST OF HAY PRODUCTION AND PROFITS.

The actual cost of establishing a timothy meadow is usually relatively small, for the reason that the seed is generally sown with some grain used as a nurse crop; the work expended in preparing the soil for the grain crop also prepares it for seeding the meadow. When a meadow is kept for two years or more there is no additional cost for the preparation of the soil in the second and following years.

The use of the land is one of the largest items, if not the largest item, involved in the cost of producing hay; it constitutes a larger proportion of the cost of production than in the case of any other farm crop. In a survey made in New York State on 12 farms in 1912 and on 23 farms in 1913 the Cornell University Agricultural Experiment Station found that the use of the land represented on the average from 29 to 30 per cent of the total cost of producing the hay crop on these farms.

The value of the labor required is usually the next largest item in the cost of producing timothy hay. The Cornell station found on the group of farms referred to in the preceding paragraph that the cost of man and horse labor was from 26 to 27 per cent of the total cost of producing the crop. The hay crop has a smaller proportion of its total cost in labor than have most of the crops grown.

On medium fertile soils which are also well suited to the production of corn and small grains, the figures quoted above may be regarded as fairly representative of the relative cost of land and labor in growing timothy. On very cheap lands, however, these values may be reversed and the cost for labor may exceed the charge made for the use of the land.

If fertilizers are used, these are likely to be the next largest item in the cost of growing timothy hay. The cost of the seed, the use

of the machinery required, the use of buildings for storing the hay, and other miscellaneous charges make up the remainder of the cost of producing the crop.

In investigations conducted by the Cornell Agricultural Experiment Station the total cost of producing the hay crop was $12.58 per acre in 1912 and $12.31 in 1913. The total cost of producing mixed timothy and clover hay in Minnesota, including harvesting the second crop of clover for hay, during the years from 1908 to 1912 varied in three different counties in that State from $7.73 to $10.75 per acre. The cost of producing timothy, like that of other crops, has, of course, increased since that time.

The average values per acre on the farms where they were grown of the hay crop and of several others of the most important crops produced in the United States are presented in Table III. These figures are quoted from the Yearbook of the United States Department of Agriculture for 1920, and they represent the average farm values of these crops for the 5-year period from 1915 to 1919, inclusive.

TABLE III.—*Average farm value per acre of hay compared with the farm values of some other crops during the 5-year period from 1915 to 1919, inclusive.*

Corn	$28.53	Oats	$19.89
Wheat	24.60	Barley	23.09
Rye	19.12	Hay	24.47

Because of the low cost of producing hay, timothy is often one of the most profitable of farm crops.

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